DRAFT REPORT

IN-DELTA STORAGE PROGRAM BORROW AREA GEOTECHNICAL REPORT

Prepared for
Department of Water Resources
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Sacramento, CA 94236

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26814170

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1.1 BACKGROUND AND PURPOSE OF STUDY

The Department of Water Resources (DWR) is conducting feasibility-level engineering and environmental studies under the Integrated Storage Investigations Programs. As part of the project evaluations, DWR is evaluating the technical feasibility and conducting engineering investigation for the In-Delta Storage Program. Engineering investigation will aim at developing solutions to enhance project reliability through improved embankment design and consolidation of inlet and outlet structures.

As part of this feasibility study, the Department requested that URS Corporation (URS) undertake a study to identify and delineate feasible borrow areas within Webb Tract and Bacon Islands, and assess the adequacy of available borrow materials for earthwork related to the planned project. The work was conducted in accordance with all applicable standards and guidelines contained in Standard Agreement No. 4600001747 and in coordination with Department staff.

The work included identifying feasible borrow sites within Webb Tract and Bacon Island, assessing the suitability of the soils as borrow materials for earthwork, estimating the volume of borrow materials available from each identified location, and comparing the total quantity of suitable borrow material available at each island with the earthwork planned at the island. For the purpose of this study a "feasible borrow site" is defined as a site where the top surface of a geotechnically-acceptable borrow soil deposits occur within a depth of 15 feet below existing ground surface and where dewatering requirements related to borrow operation are expected to be low.

1.2 SCOPE OF WORK

The scope of work was described in Task Order No. IDS-1102-1747-006 by DWR dated November 15, 2002. The scope of work is summarized below:

- Collect and review existing information.
- Perform a field investigation consisting of 20 borings extending to depths of 15 to 20 feet on Webb Tract and Bacon Island to supplement the existing Cone Penetrometer Test (CPT) and soil boring data.
- Log the soil conditions and depth to borrow materials and groundwater encountered in the borings. Present the results on Logs of Borings (Appendix A).
- Perform laboratory testing consisting of sieve analysis, moisture content determination, and Atterberg limits (Appendix B).
- Estimate the locations of borrow sites within each island.
- Estimate the volume of borrow soils available at each island and compare to planned earthwork volume.

2.1 SITE LOCATIONS AND ACCESSBILITY

Webb Tract and Bacon Islands are located in the Sacramento – San Joaquin River Delta, near Stockton, California. A site vicinity map is shown in Figure 1. Webb Tract is located at the northeast corner of the Contra Costa County limit near Oakley, California. The island is accessible by ferry. The ferry station is located on the northeast corner of Jersey Island on the False River side. The ferry station is accessible to vehicles by taking the Jersey Island Road from the Cypress Road off California Highway 4 in Oakley. The ferry operates once every hour starting at 8:00 A.M. until 5:00 P.M. with no service at 12:00 P.M. Bacon Island is located within the San Joaquin County near Stockton, California. The island is accessible to vehicles by taking the Bacon Island Road off California Highway 4. A reinforced concrete bridge links the island to the Bacon Island Road at the southeast corner of the island on the Middle River side.

2.2 SURFACE CONDITIONS

The Sacramento-San Joaquin River Delta was developed for agricultural purposes from a tidal marsh in 1800s. As part of the development, levees were constructed on the underlying peat and soft clay to form islands. The existing channels were improved, and new channels were dredged.

Webb Tract and Bacon Island encompass about 5,500 acres and 5,600 acres, respectively. The ground elevation of both Webb Tract and Bacon Island, initially, was near sea level. Land subsidence has steadily decreased the surface elevation primarily as a result of the loss of organic material and peat. The loss is caused by exposure of peat to oxygen (oxidation), wind erosion, burning as well as some other factors. The ground surface elevation on most part of Webb Tract and Bacon Island at present ranges from about –10 feet to lower than –15 feet.

Farming is a primary land use on both islands. The interiors of both islands were divided and linked by unpaved embankment roads to agricultural area and irrigation ponds. Ditches were excavated throughout the islands as part of the irrigation and drainage systems. The sites are mostly covered with plowed soil for future crop growing or dried crops left from the previous harvest. Areas with no agricultural use are covered with grass and shrubs. Many parts of the islands are marshy, especially on Webb Tract.

As part of this study, the following documents were reviewed:

- Borrow Sites, Staged Filling and Slough-side Slope Stability, Delta Wetlands Reservoirs, Contra Costa County and San Joaquin County, California, dated July 25, 2002, prepared by Hultgren-Tillis Engineers.
- Bureau of Reclamation Cone Penetrometer Test data for the In-Delta Storage Program conducted during August to September 2002.
- Preliminary Geotechnical Investigation, Delta Wetlands Project, Sacramento-San Joaquin River Delta, Volume 1 of 2, dated February 15, 1989, prepared by Harding Lawson Associates (HLA).

The July 2002 Hultgren-Tillis report presents a preliminary evaluation of the potential borrow areas and volume of borrow materials from Webb Tract, Bacon Island and two other islands. The report also discusses construction aspects involving material handling, levee filling, and slope stability.

The Bureau of Reclamation conducted CPT soundings within the interiors of both islands during August and September 2002. The locations of the CPT soundings are shown on Figure 2 (Webb Tract) and Figure 3 (Bacon Island). The CPT data were used to supplement the data gathered as a part of this study. The CPT logs from the Bureau of Reclamation are presented in Appendix C.

The February 1989 HLA report presents subsurface soil data for both Webb Tract and Bacon Island that includes boring logs, Cone Penetrometer Test (CPT) sounding logs and laboratory test results. HLA conducted seven rotary-wash borings on Webb Tract and eight rotary-wash borings on Bacon Island. The locations of these borings are shown on Figure 2 (Webb Tract) and Figure 3 (Bacon Island). The depth of these borings ranges from 41.5 to 101.5 feet below the existing ground surface. The logs of the HLA borings are presented in Appendix D. CPT soundings conducted as part of the HLA 1989 report were on the perimeter of the islands and, therefore, were not considered in this study.

The subsurface soil data presented in the previous studies indicates that a layer of peat and fat clay of variable thickness was encountered in the upper part of the soil stratigraphy within the islands. The thickness of this layer ranges from a few feet to about 40 feet. This peat and clay layer is underlain by a layer of gray silty fine sand and sandy silt, which would be the borrow materials. In some areas on the west side of Webb Tract, sand is exposed at the ground surface.

4.1 FIELD EXPLORATION

The field exploration program for this study included a field reconnaissance and geotechnical exploratory borings and sampling. Ten exploratory borings were drilled on each island as shown on Figure 2 (Webb Tract) and Figure 3 (Bacon Island). URS prepared a geotechnical exploration work plan including exploration site maps.

A URS engineer and a DWR environmental scientist conducted a geotechnical and environmental field reconnaissance on Webb Tract and Bacon Island during December 5 and 6, 2002. The objectives of the field reconnaissance were to locate the borehole locations and to examine a 50-foot radius circle around each drilling site for potential burrows or surface cracks. The drilling locations were adjusted to maintain a minimum of 50-foot radius clear of burrows or surface cracks. Drilling sites were located on disturbed areas, either on or adjacent to farm roads or on active agricultural fields.

DWR informed URS regarding the environmental and archeological restrictions related to the proposed field exploration, and issued an environmental clearance memorandum dated December 10, 2002. Permission to enter Webb Tract and Bacon Island for the proposed field exploration was issued by DWR letter dated December 9, 2002. Prior to performing the field explorations, Underground Service Alert (USA) was notified of the boring locations, and underground utilities were cleared by USA.

Ten exploratory soil borings totaling 165 linear feet were drilled on each island for this geotechnical study during December 11 and 12, 2002. These borings are designated W-1 to W-10 for Webb Tract and B-1 to B-10 for Bacon Island. The locations of the borings are shown on Figure 2 (Webb Tract) and Figure 3 (Bacon Island). The borings ranged in depth from 15 to 19 feet below the existing ground surface (BGS). The borings were drilled using a truck-mounted CME-45 drilling rig owned and operated by Taber Consultants Engineers and Geologists of West Sacramento, California. The borings were advanced using a 4-inch diameter solid stem auger.

A URS engineer logged the soil cuttings and samples in the field and visually classified the soils, as the drilling proceeded. Samples of the subsurface materials were obtained at selected depths in the borings using a Standard Penetration Test (SPT) split-spoon sampler with an outside diameter of 2 inches and inside diameter of 1.5 inches as shown in the Key to Log of Boring (Figure A-1 in Appendix A). The sampler was advanced with a 140-pound hammer lifted manually by a cathead-rope system with a 30-inch drop. Soil samples were collected of the potential borrow materials that were visually classified as sand, silty sand, clayey sand, sandy clay, or sandy silt. The sampling intervals were 2.5 feet or 5 feet within the potential borrow materials.

The recovered samples were taken to the URS geotechnical laboratory in Pleasant Hill for further visual examination and testing. Logs of Borings were prepared based on the field logs, the visual examination in the laboratory, and the laboratory testing results, and are presented in Figures A-2 through A-21 in Appendix A. Descriptions of the procedures used to drill the borings, and to obtain soil samples are in Appendix A (URS Corporation 2002 Geotechnical Drilling and Sampling Program).

4.2 LABORATORY TESTING

Selected soil samples obtained from the exploratory borings were tested in our Pleasant Hill geotechnical laboratory to evaluate their engineering properties for use in the borrow material evaluations. The following laboratory tests were performed on selected soil samples:

- Grain size analyses (ASTM D422)
- Water content determination (ASTM D2216)
- Atterberg limits determination (ASTM D4318).

The results of the geotechnical laboratory testing are summarized in the logs of borings at the corresponding sample depths. Geotechnical laboratory test results are presented in Appendix B (URS Corporation 2002 Geotechnical Laboratory Test Results).

5.1 WEBB TRACT

5.1.1 Subsurface Soil Conditions

The subsurface conditions encountered in the exploratory borings drilled for this study are generally consistent with those encountered in the previous borings and CPT data in Webb Tract. The subsurface conditions generally consist of a layer of very soft, high plasticity, dark brown to black highly organic soil of variable thickness with interbedded peat. The near surface soil appears to be lighter in color due to higher degree of oxidation. The thickness of this highly organic soil and peat layer ranges from a few feet to more than 15 feet. Based on the conditions encountered in the exploratory borings for this study and the existing borings and CPT data, the thickness of peat appears to be thinner on the west side of Webb Tract.

The dark brown to black highly organic soil and peat layer is underlain by a gray, silty sand (SM and SP-SM) layer that extends to the depth explored. This material varied in consistency from loose to medium dense and contained interbedded thin layers of gray sandy silt. The results of laboratory testing in this material indicate that the silty sand is poorly graded consisting of fine-grained sand, with low plasticity interbedded sandy silt. There are large areas on the west side of the island where brown silty sand is exposed at the ground surface as encountered in Boring W-8.

The laboratory testing data (Appendix B) of the soil materials indicate that the silty sand is poorly graded with 5% to 38% fines (materials passing the No. 200 U.S. Standard Sieve). The water contents of the silty sandy soils ranged from 18% to 23%.

The depths to potential sandy borrow materials at the boring and CPT locations in Webb Tract are presented in Table 5-1.

5.1.2 Groundwater Conditions

The level of groundwater encountered at the time of drilling in the borings in Webb Tract varied from about 2 feet to 9 feet below the ground surface. Groundwater levels in most parts of the island were encountered around 2 feet to 5 feet below the ground surface. The groundwater was not encountered in Boring W-8 due to higher elevation of the ground surface. The groundwater levels are largely affected by the irrigation and drainage system within the island. The ground surface elevation within most of the island is lower than sea level, and the water level outside the perimeter of the island is higher than the ground surface of the island. Static groundwater levels were not recorded due to the immediate backfill of the borings with soil cuttings.

5.2 BACON ISLAND

5.2.1 Subsurface Soil Conditions

The subsurface conditions encountered in the exploratory borings drilled for this study are consistent with those encountered in the previous borings and CPT data in Bacon Island. The subsurface conditions at the site generally consist of a layer of very soft, high plasticity, dark brown to black highly organic soil of variable thickness with interbedded peat. The near surface

soil appears to be lighter in color due to higher degree of oxidation. The thickness of this highly organic soil and peat layer ranges from a few feet to about 15 feet in the borings drilled for this study. The thickness of this layer varies throughout the interior of the island with some thinner areas on the north and south parts of the island.

The dark brown to black highly organic soil and peat layer is underlain by a gray, silty sand (SM) layer that extends to the depth explored. This material varied in consistency from loose to medium dense and contained interbedded thin layers of gray silty clay. The results of laboratory testing indicate the silty sand is poorly graded consisting of fine-grained sand, with the interbedded silty clay of medium to high plasticity.

The laboratory testing data (Appendix B) of the soil materials indicate that they contain 18% to 74% fines (materials passing the No. 200 U.S. Standard Sieve). The water contents of the materials ranged from 20% to 40%. The silt and clay contents and the water contents in the materials encountered in Bacon Island are higher than for the materials encountered in Webb Tract.

The depths to potential sandy borrow materials at the boring and CPT locations in Bacon Island are presented in Table 5-2.

5.2.2 Groundwater Conditions

The level of the groundwater encountered at the time of drilling in the borings in Bacon Island varied from about 3 feet to 13 feet below the ground surface. Based on the water levels measured at the time of drilling, the groundwater levels in Bacon Island are deeper than in Webb Tract. The groundwater levels are largely affected by the irrigation and drainage system within the island. Static groundwater levels were not recorded due to the immediate backfill of the borings with soil cuttings.

Table 5-1. Webb Tract - Depth to Potential Borrow Materials

HLA Boreholes (2002)		Bureau of Reclamation (2002) CPT		URS Boreholes (2002)	
Boring No.	Depth (ft BGS)	CPT No.	Depth (ft BGS)	Boring No.	Depth (ft BGS)
WE 1	0	WSC-1	10	W-1	>15
WE 2	30	WSC-2	7	W-2	11
WE 3	19	WSC-3	5	W-3	12.5
WE 4	11.5	WSC-4	11	W-4	>15
WE 5	13.5	WSC-5	2	W-5	6
WE 6	36.5	WSC-6	10	W-6	9
WE 6A	37	WSC-7	11	W-7	13
WE 7	18	WSC-8	14	W-8	0
		WSC-9	17	W-9	14
		WSC-10	17	W-10	10
		WSC-11	42		
		WSC-13	39		
		WSC-15	41		
		WSC-16	16		
		WSC-17	23		
		WSC-18	19		
		WSC-19	7		

Note: No CPT at WSC-12 and WSC-14

Table 5-2. Bacon Island - Depth to Potential Borrow Materials

HLA Boreholes (2002)		Bureau of Reclamation (2002) CPT		URS Boreholes (2002)	
Boring No.	Depth (ft BGS)	CPT No.	Depth (ft BGS)	Boring No.	Depth (ft BGS)
BA 1	28	BSC-1	22	B-1	9 to 13
BA 2	19	BSC-2	16	B-2	12
BA 3	11	BSC-6	9	B-3	5.5
BA 4	9	BSC-7	18	B-4	12.5
BA 5	35	BSC-8	20	B-5	7.5
BA 6	17	BSC-9	11	B-6	7.5
BA 7	16	BSC-10	19	B-7	15
BA 8	8	BSC-12	7	B-8	15
		BSC-13	24	B-9	11.5
		BSC-15	21	B-10	15
		BSC-16	9		
		BSC-17	12		
		BSC-18	17		

Note: No CPT at BSC-3, BSC-4, BSC-5, BSC-11, and BSC-14

6.1 ESTIMATED AVAILABLE BORROW VOLUMES

The potential borrow areas in Webb Tract and Bacon Island were delineated based on maintaining a distance of at least 1500 feet between the borrow areas and the crests of the existing island levees, and encompassing areas that have no more than 15 feet to the top of potential sandy borrow materials. The borrow area delineations are shown on Figures 4 and 5 for Webb Tract and Bacon Island, respectively. These figures also show the depths to the top of sandy borrow materials adjacent to the borings and CPT's.

The borrow area limits were set to maximize the potential materials available within each island and do not necessarily mean that the entire areas within the borrow areas would be utilized. Borrow area utilization would depend on the contractor's operation plans and excavation conditions encountered during construction.

Several cross sections were drawn through each borrow area and the volumes of potential borrow materials within each island were estimated using average end area methods. Table 6-1 summarizes the areas of the potential borrow areas, estimated volume to remove peat and other unacceptable overburden soils, estimated borrow material volumes available within 15 feet of the ground surface, and ratios of overburden volume to borrow volume.

Table 6-1. Summary of Available Borrow Volume Estimates

Estimated Area/Volume	Webb Tract	Bacon Island
Delineated Area (acres)	2330	2620
Volume of Overburden Excavation (CY)	36.9 million	49.6 million
Volume of Potential Borrow Materials within 15 feet of the Ground Surface (CY)	19.5 million	13.8 million
Ratio of Overburden Volume to Borrow Volume	1.9:1	3.6:1

The estimated available volumes will be compared to the required volumes in a separate report on construction and cost estimates.

6.2 BORROW DEVELOPMENT CONSIDERATONS

As mentioned in Section 6.1, the borrow area limits shown on Figures 4 and 5 are the maximum potential areas within each island. Specific areas within each island to be utilized would depend on the contractor's operation plans and excavation conditions encountered during construction to make use of the most readily available materials. A trade-off would need to be made between haul distance and excavation of overburden materials.

It is expected that the contractor would develop sections within each borrow area to minimize haul distances and to make use of the materials with the least amount of overburden stripping. The ratios of overburden volume to borrow volume shown in Table 6-1 indicate that there would

be a significant amount of stripping required to obtain the borrow materials. Stripped materials would be stockpiled for subsequent placement in the depleted sections of the borrow areas.

It is anticipated that the sandy borrow materials would be mined by excavators, mostly below groundwater level, and stockpiled to drain. Groundwater may be as shallow as 2 feet or 3 feet below the ground surface. Moisture conditioning of the soils may require disking and aerating. After the soils are moisture conditioned for compaction, they would be hauled to the embankment locations along the perimeters of the islands.

The scope of work for this study included identifying feasible borrow sites within Webb Tract and Bacon Island, assessing the suitability of the soils as borrow materials for earthwork, estimating the volume of borrow materials available from each identified location. The estimated available borrow volumes will be compared to the required volumes in a separate report on construction and cost estimates.

The field exploration program for this study included drilling ten exploratory borings on each island that ranged in depth from about 15 feet to 20 feet. The soil samples from the borings were tested to obtain data on grain size, water contents and Atterberg limits. Boring logs were prepared of each boring and are included in this report, along with the laboratory testing data. In addition, boring logs and CPT logs prepared by others are included in this report.

On both islands, there is a highly organic soil and peat layer that ranges from a few feet to more than 15 feet thick. On Webb Tract, this layer is underlain by gray, silty sand (SM and SP-SM) that extends to the depth explored. This material varied in consistency from loose to medium dense and contained interbedded thin layers of gray sandy silt. On Bacon Island, the organic soil and peat layer is underlain by a gray, silty sand (SM) layer that extends to the depth explored. This material varied in consistency from loose to medium dense and contained interbedded thin layers of gray silty clay. The silt and clay contents and the water contents in the materials encountered in Bacon Island are higher than for the materials encountered in Webb Tract.

The level of groundwater encountered at the time of drilling in the borings in Webb Tract varied from about 2 feet to 9 feet below the ground surface with most levels around 2 feet to 5 feet below the ground surface. The level of the groundwater encountered at the time of drilling in the borings in Bacon Island varied from about 3 feet to 13 feet below the ground surface. Based on the water levels measured at the time of drilling, the groundwater levels in Bacon Island are deeper than in Webb Tract. The groundwater levels are largely affected by the irrigation and drainage system within the islands. Static groundwater levels were not recorded due to the immediate backfill of the borings with soil cuttings. Accordingly, the static water levels are expected to be shallower than those measured at the time of drilling.

The borrow area limits were set to maximize the potential materials available within each island. Borrow area utilization would depend on the contractor's operation plans and excavation conditions encountered during construction. It is anticipated that the sandy borrow materials would be mined by excavators, mostly below the groundwater level, and stockpiled to drain.

The potentially available borrow materials within 15 feet of the ground surface in Webb Tract are estimated to total about 19.5 million cubic yards and for Bacon Island, the potentially available borrow materials are estimated to total about 13.8 million cubic yards. The exploration data indicate that there would be a significant amount of stripping required to obtain the borrow materials. Borrow excavation and embankment construction are covered in the URS Earthwork Construction Cost Estimate report (April 2003).

For further development of the In-Delta Storage embankments, supplemental drilling, laboratory testing, and CPT soundings should be performed in the potential borrow areas. Standpipe piezometers should be installed in selected borings to measure groundwater levels.

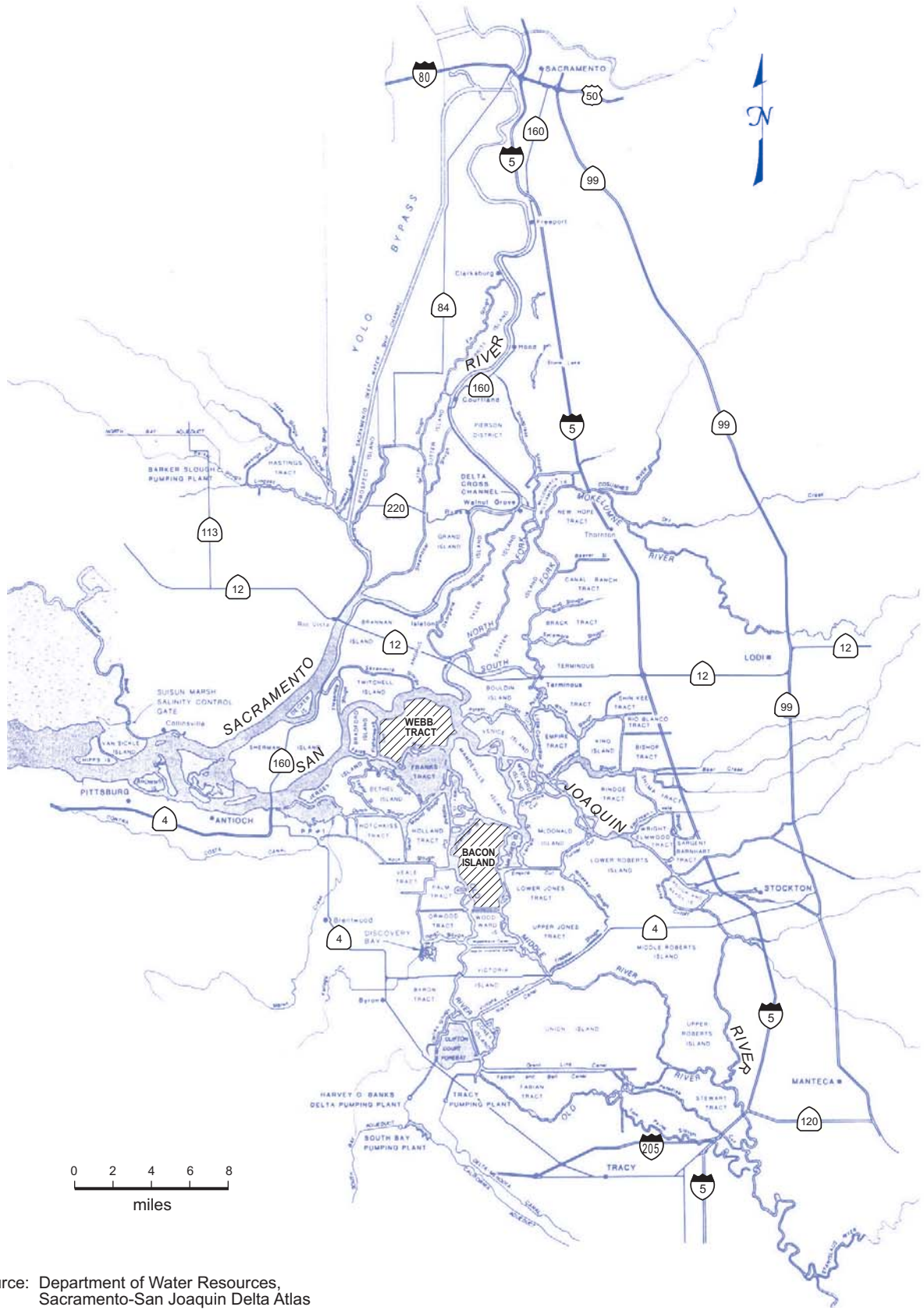
This geotechnical study has been conducted in accordance with the standard of care commonly used as state-of-practice in the profession. No other warranties are either expressed or implied. The recommendations presented in this report are developed exclusively for the proposed potential borrow areas described in this report and are not valid for other locations and construction in the project vicinity. The recommendations made in this report are based on the assumption that the subsurface soil and groundwater conditions do not deviate appreciably from those disclosed in the exploratory borings. If any variations or undesirable conditions are encountered during construction, URS should be notified so that additional recommendations can be made.

Bureau of Reclamation (2002). Logs of CPT Soundings, August and September.

California Department of Water Resources (1998). "Sacramento San Joaquin Delta Atlas", Department of Water Resources, California, July 1995.

Harding Lawson Associates (1989). "Preliminary Geotechnical Investigation, Delta Wetlands Project, Sacramento-San Joaquin River Delta", Concord California, prepared for Delta Wetlands, February 15, 1989.

Hultgren-Tillis Engineers (2002). "Borrow Sites, Staged Filling and Slough-side Slope Stability, Delta Wetlands Reservoirs, Contra Costa County and San Joaquin County, California", Volume 1 of 2, Concord, California, prepared for Delta Wetlands, July 25, 2002.



Source: Department of Water Resources, Sacramento-San Joaquin Delta Atlas

URS	Project No. 26814170 STATE OF CALIFORNIA DEPARTMENT OF WATER RESOURCES	SITE VICINITY	FIGURE **1**

26814170.01200/012103/gos

N

San Joaquin River

Old River

False River

Franks Tract

Fishermans Cut

R-1
R-2
R-3
R-4
R-5
R-6
R-7
R-8
R-9
R-10

WSC-1
WSC-2
WSC-3
WSC-4
WSC-5
WSC-6
WSC-7
WSC-8
WSC-9
WSC-10
WSC-11
WSC-13
WSC-15
WSC-16
WSC-17
WSC-18
WSC-19

W-1
W-2
W-3
W-4
W-5
W-6
W-7

WE1
WE2
WE3
WE4
WE5
WE6
WE7
WE8

0 2000 4000 FEET
SCALE

LEGEND:

- WE1 — HARDING LAWSON ASSOCIATES BOREHOLES (1989)
- WSC-1 — BUREAU OF RECLAMATION CPT (2002) (NO CPT'S: WSC12 AND WSC14)
- W-1 — URS BOREHOLES (2002) APPROX. LOCATION
- R-1 — ACCESS ROAD NUMBER AND LOCATION

URS

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DEPARTMENT OF WATER RESOURCES

WEBB TRACT EXPLORATION PLAN

FIGURE 2

LEGEND:

BA1	HARDING LAWSON ASSOCIATES BOREHOLES (1989)
BSC-1	BUREAU OF RECLAMATION CPT (2002) (NO CPT'S: BSC-3, BSC-4, BSC-5, BSC-11, AND BSC-14)
B-1	URS BOREHOLES (2002) APPROX. LOCATION
R-1	ACCESS ROAD NUMBER AND LOCATION

SCALE
0 2000 4000 FEET

URS

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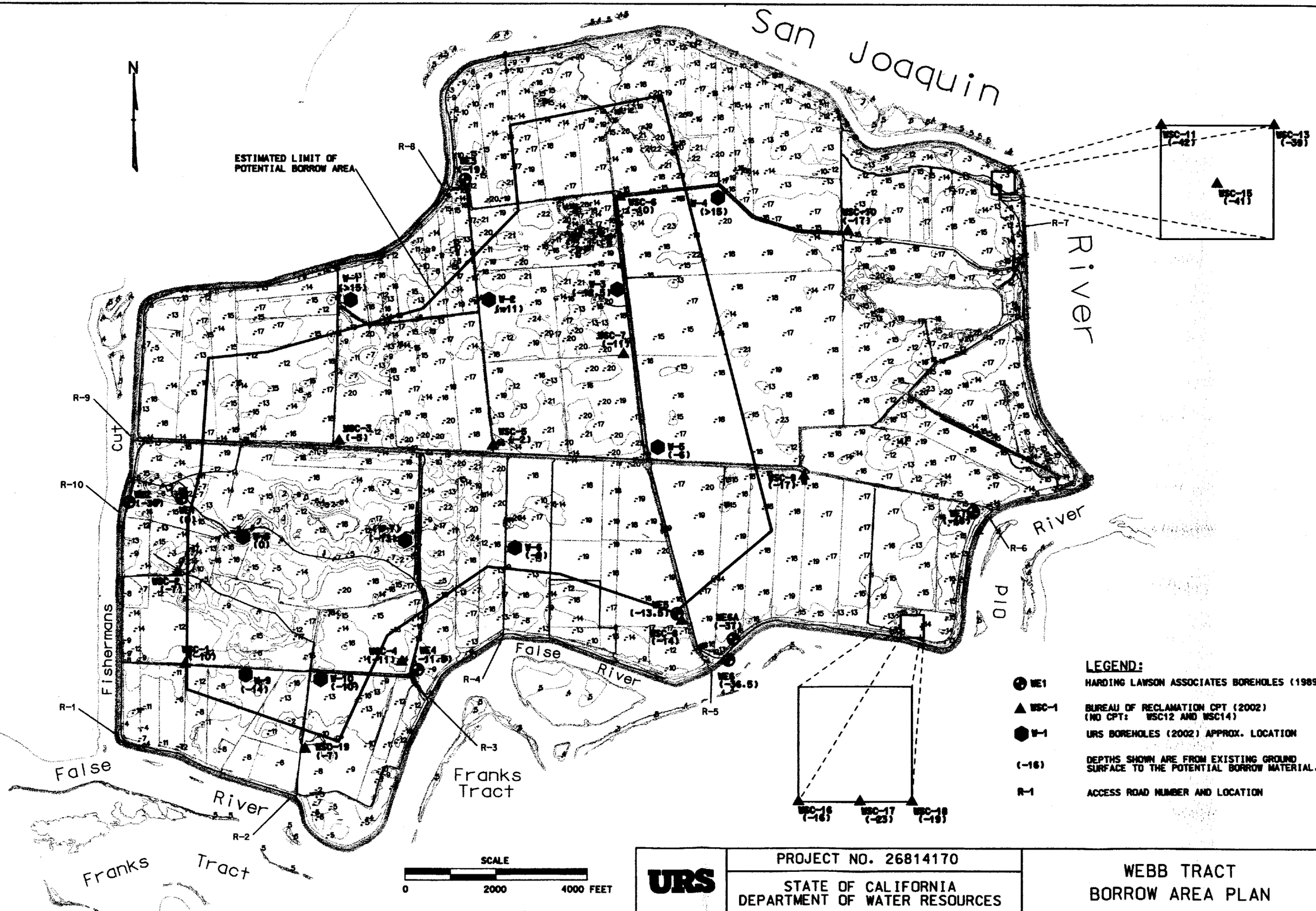
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

BACON ISLAND
EXPLORATION PLAN

FIGURE
3



URS	PROJECT NO. 26814170 STATE OF CALIFORNIA DEPARTMENT OF WATER RESOURCES	WEBB TRACT BORROW AREA PLAN	FIGURE 4

LEGEND:

BA1	HARDING LAWSON ASSOCIATES BOREHOLES (1989)
BSC-1	BUREAU OF RECLAMATION CPT (2002) (NO CPT'S: BSC-3, BSC-4, BSC-5, BSC-11, AND BSC-14)
B-1	URS BOREHOLES (2002) APPROX. LOCATION
(-16)	DEPTH SHOWN ARE FROM EXISTING GROUND SURFACE TO THE POTENTIAL BORROW MATERIAL.

SCALE
0 2000 4000 FEET

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BACON ISLAND
BORROW AREA PLAN

FIGURE
5